PATENT COOPERATION TREATY

From the INTERNATIONAL BUREAU

PCT

NOTIFICATION OF ELECTION

(PCT Rule 61.2)

To:

Commissioner
US Department of Commerce
United States Patent and Trademark
Office, PCT
2011 South Clark Place Room
CP2/5C24
Arlington, VA 22202
ETATS-UNIS D'AMERIQUE

in its capacity as elected Office

Date of mailing: 08 March 2001 (08.03.01)	
International application No.: PCT/IL99/00476	Applicant's or agent's file reference: PEA
International filing date: 01 September 1999 (01.09.99)	Priority date:
Applicant: KRITCHMAN, Eli et al	

1. The designated Office is hereby notified of its election made:

[X] in the demand filed with the International preliminary Examining Authority on:

29 August 2000 (29.08.00)

[ ] in a notice effecting later election filed with the International Bureau on:

2. The election [X] was

[ ] was not

made before the expiration of 19 months from the priority date or, where Rule 32 applies, within the time limit under Rule 32.2(b).

The International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland

Facsimile No.: (41-22) 740.14.35

Authorized officer:

J. Zahra

Telephone No.: (41-22) 338.83.38

PATENT COOPERATION TREATY

From the
INTERNATIONAL PRELIMINARY EXAMINING AUTHORITY

To:

FENSTER & COMPANY PATENT
ATTORNEYS, LTD
P.O.Box 10256
Petach Tikva 49002
ISRAEL

PCT

NOTIFICATION OF TRANSMITTAL OF
THE INTERNATIONAL PRELIMINARY
EXAMINATION REPORT
(PCT Rule 71.1)

Date of mailing *(day/month/year)*	06.12.2001
Applicant's or agent's file reference PEA	**IMPORTANT NOTIFICATION**

International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL99/00476	01/09/1999	01/09/1999

Applicant
INDIGO N.V. et al.

1. The applicant is hereby notified that this International Preliminary Examining Authority transmits herewith the international preliminary examination report and its annexes, if any, established on the international application.

2. A copy of the report and its annexes, if any, is being transmitted to the International Bureau for communication to all the elected Offices.

3. Where required by any of the elected Offices, the International Bureau will prepare an English translation of the report (but not of any annexes) and will transmit such translation to those Offices.

4. **REMINDER**

The applicant must enter the national phase before each elected Office by performing certain acts (filing translations and paying national fees) within 30 months from the priority date (or later in some Offices) (Article 39(1)) (see also the reminder sent by the International Bureau with Form PCT/IB/301).

Where a translation of the international application must be furnished to an elected Office, that translation must contain a translation of any annexes to the international preliminary examination report. It is the applicant's responsibility to prepare and furnish such translation directly to each elected Office concerned.

For further details on the applicable time limits and requirements of the elected Offices, see Volume II of the PCT Applicant's Guide.

Name and mailing address of the IPEA/	Authorized officer
European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Maier, E Tel.+49 89 2399-2230

Form PCT/IPEA/416 (July 1992)

PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
PEA		
International application No.	International filing date *(day/month/year)*	Priority date *(day/month/year)*
PCT/IL99/00476	01/09/1999	01/09/1999
International Patent Classification (IPC) or national classification and IPC G01J3/46		
Applicant INDIGO N.V. et al.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 7 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 2 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the report
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☒ Lack of unity of invention
   - V ☒ Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations suporting such statement
   - VI ☐ Certain documents cited
   - VII ☒ Certain defects in the international application
   - VIII ☒ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
29/08/2000	06.12.2001
Name and mailing address of the international preliminary examining authority: European Patent Office D-80298 Munich Tel. +49 89 2399 - 0 Tx: 523656 epmu d Fax: +49 89 2399 - 4465	Authorized officer Schmidt, C. Telephone No. +49 89 2399 2254

Form PCT/IPEA/409 (cover sheet) (January 1994)

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

International application No. PCT/IL99/00476

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:
Description, pages:

1-11	as originally filed				

Claims, No.:

17-19	as originally filed				
1-16	as received on	22/11/2001	with letter of	22/11/2001	

Drawings, sheets:

1/3-3/3	as originally filed				

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   - ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).
   - ☐ the language of publication of the international application (under Rule 48.3(b)).
   - ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   - ☐ contained in the international application in written form.
   - ☐ filed together with the international application in computer readable form.
   - ☐ furnished subsequently to this Authority in written form.
   - ☐ furnished subsequently to this Authority in computer readable form.
   - ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.
   - ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

☐ the description, pages:

☐ the claims, Nos.:

☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)):

(Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

IV. Lack of unity of invention

1. In response to the invitation to restrict or pay additional fees the applicant has:

☐ restricted the claims.

☐ paid additional fees.

☐ paid additional fees under protest.

☐ neither restricted nor paid additional fees.

2. ☒ This Authority found that the requirement of unity of invention is not complied and chose, according to Rule 68.1, not to invite the applicant to restrict or pay additional fees.

3. This Authority considers that the requirement of unity of invention in accordance with Rules 13.1, 13.2 and 13.3 is

☐ complied with.

☒ not complied with for the following reasons:
see separate sheet

4. Consequently, the following parts of the international application were the subject of international preliminary examination in establishing this report:

☒ all parts.

☐ the parts relating to claims Nos. .

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims 1 - 19
	No:	Claims

Inventive step (IS)	Yes:	Claims	1 - 19
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1 - 19
	No:	Claims	

2. Citations and explanations
see separate sheet

VII. Certain defects in the international application

The following defects in the form or contents of the international application have been noted:
see separate sheet

VIII. Certain observations on the international application

The following observations on the clarity of the claims, description, and drawings or on the question whether the claims are fully supported by the description, are made:
see separate sheet

CITED DOCUMENTS

D1: EP-A-0 669 754 (DAINIPPON SCREEN MFG) 30 August 1995 (1995-08-30)
D2: DE 32 21 812 A (GRETAG AG) 5 January 1983 (1983-01-05)
D3: US-A-5 003 500 (W. H. GERBER) 26 March 1991 (1991-03-26)

SECTION IV: LACK OF UNITY

The separate groups of invention are:

Claims 1-10 and 18-19: these claims are directed to a method of determining an adjusted colour to be used for printing on a substrate wherein the diffuse reflection of the colorant is taken into account in the calculations.

Claims 11 - 17: these claims are directed to a method of determining the optical density of a printed colorant wherein to compensate for the effect of saturation an "incorrect" filter, ie a filter at a wavelength where there is no saturation, is used.

They are not so linked as to form a single general inventive concept (Rule 13.1 PCT) since they are directed to solve two different problems in connection with reproduction of colour, ie the influence of the diffuse reflection and the effect of saturation when determining the optical density. These problems are independent in the art of colour reproduction and not linked to each other. Further, also the solutions - ie in one case measuring the diffuse reflection separately and in the other case to measure the density at a wavelength outside saturation area - are independent and not linked to each other. Thus, there are no common or corresponding specific technical features as required by Rule 13.2 PCT linking the groups of claims.

SECTION V

In the following the claims have been interpreted as stated under Section VIII regarding clarity of the claims.

First group of claims (1-10, 18-19)

1.1 Claim 1 concerns a method of determining an adjusted colour.

1.2 Document D1, which is considered as the closest prior art, discloses a method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, wherein the specular reflectance as well as the internal scattered light is measured of a colorant.

1.3 Claim 1 differs from this document in that not the internally scattered light is measured but the diffusely reflected light from the outer surface of the colorants when printed on a specified substrate. Thus, claim 1 is novel.

1.4 The idea behind this is that the appearance of the final print to the user depends on two different kinds of diffuse reflections: one is the diffuse reflection from the surface of the colorant and the other is the diffuse reflection from the underlying substrate after it passes twice through the colorant.

1.5 In D1 also the reflectance from the outer surface is measured, however, in D1 there is no teaching to separate the diffuse and specular reflectance from the surface but rather, according to the formulas, what is measured is the sum of both specular and diffuse light.

1.6 Since there is no hint in the cited art at the separation of only diffuse light from the outer surface of the colorants, the subject-matter of claim 1 is also considered inventive.

1.7 The dependent claims 2 to 10 concern specific embodiments of claim 1 and are therefore also considered novel and inventive.

2. Claims 18 and 19 are concerned with a method of measuring the diffused reflection from the surface of the colorant. Although documents D1 and D2 talk about measuring on solidly printed or "Vollton" prints they are not concerned with the measurement of the diffuse reflection from the surface.

Second group of claims (11 to 17)

This group of claims is directed at a method of determining the optical density of a printed colorant using a wavelength region in which the color is not near or at saturation. Such a method is neither disclosed nor hinted at in the prior art.

SECTION VII

The claims should have been drafted in accordance with Rule 6.3 b (two-part form) and 6.2 b (reference signs in claims) PCT, taking into consideration the document D1 above. The documents D1 to D3 should have been acknowledged in the introductory part of the description pursuant to Rule 5.1 a) ii) PCT.

SECTION VIII

1. In claim 1 it should have been clarified that the diffuse relfection from the outside surface is estimated separated from the specular reflection and separated from the diffuse reflection of the surface of the substrate (see also p. 2, lines 25-27) in order to clearly define the subject-matter of the claim.

2. In claim 2 the expression "wherein the specified color is a color spectrum" is not clear.

3. Claim 13 and 14 refer to both claims 11 and 12. However, since claim 12 deals with the case of the color not being saturated and thus measured conventionally the reference in claims 13 and 14 to claim 12 is obscure.

10/070237
JC13 Rec'd PCT/PTO 28 FEB 2002

CLAIMS

1. A method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, comprising:

specifying an apparent color;

estimating diffuse reflection from an outside surface of colorants when printed on the specified substrate; and

adjusting the specified color for the effects of the estimated diffuse reflection to determine a color to be used for computing the colorants.

2. A method according to claim 1 wherein the specified color is a color spectrum.

3. A method according to claim 1 or claim 2 wherein the specified apparent color is determined from a measurement of a printed exemplar.

4. A method according to any of the preceding claims and including determining a mixture of colorants based on the adjusted spectrum.

5. A method according to claim 4, including:

printing the mixture of colorants as separate separations on the substrate.

6. A method according to claim 5 wherein the separations are printed as half-tone configurations.

7. A method according to claim 5 or claim 6 wherein the colorants comprise at least one process color.

8. A method according to any of claims 5-7 wherein determining the mixture of color components comprises determining a percent coverage of the colorants of the separations on the substrate.

9. A method according to any of claims 5-8 and including correcting the estimate of diffuse reflection based on a percent coverage of the substrate by the colorants and repeating the determination of the color mixture based on the corrected estimate.

10. A method according to claim 4 and including printing the mixture of colorants as a single layer of mixed colorant.

11. A method of determining the OD of a printed colorant, comprising:

determining a visible wavelength region in which the color is at or near saturation; and

if a portion of a determination of saturation is found, determining the OD in a wavelength region at which the color is not at or near saturation.

12. A method according to claim 11 and including, if none of the visible wavelength region is at or near saturation:

determining the OD in a wavelength region at which the spectrum of light reflected from the colorant is a minimum.

13. A method according to claim 11 or claim 12 and comprising:

acquiring a reflection spectrum of the printed colorant including at least a wavelength region in which the color is not at or near saturation, wherein the OD is determined based on a reflectance measurement at a wavelength in which the color is not at or near saturation.

14. A method according to claim 11 or claim 12 wherein determining the OD comprises:

filtering the reflection through a filter which passes at least a portion of the wavelength region in which the color is not at or near saturation; and

measuring the filtered reflection.

15. A method of choosing a filter for performing the method of claim 14 from a plurality of filters, comprising:

determining which of the filters in the plurality of filters blocks a maximum amount of the reflected light without saturation of the measurement; and

utilizing the thus determined filter to filter the reflection prior to measurement.

16. A method according to claim 14 or claim 15, wherein the colorant is a process color and wherein the plurality of filters comprise a filter associated with each of the process colors, each said filter selectively passing only wavelengths for which the colorant has a high absorption and including:

PATENT COOPERATION TREATY

From the INTERNATIONAL SEARCHING AUTHORITY

PCT

NOTIFICATION OF TRANSMITTAL OF THE INTERNATIONAL SEARCH REPORT OR THE DECLARATION

(PCT Rule 44.1)

To:
FENSTER & COMPANY PATENT
ATTORNEYS, LTD
Attn. FENSTER, PAUL.
P.O.Box 10256
Petach Tikva 49002
ISRAEL

Applicant's or agent's file reference PEA	Date of mailing *(day/month/year)* 04/05/2000 **FOR FURTHER ACTION** See paragraphs 1 and 4 below
International application No. PCT/IL 99/00476	International filing date *(day/month/year)* 01/09/1999
Applicant INDIGO N.V. et al.	

1. [X] The applicant is hereby notified that the International Search Report has been established and is transmitted herewith.

Filing of amendments and statement under Article 19:
The applicant is entitled, if he so wishes, to amend the claims of the International Application (see Rule 46):

When? The time limit for filing such amendments is normally 2 months from the date of transmittal of the International Search Report; however, for more details, see the notes on the accompanying sheet.

Where? Directly to the International Bureau of WIPO
34, chemin des Colombettes
1211 Geneva 20, Switzerland
Fascimile No.: (41-22) 740.14.35

For more detailed instructions, see the notes on the accompanying sheet.

2. [ ] The applicant is hereby notified that no International Search Report will be established and that the declaration under Article 17(2)(a) to that effect is transmitted herewith.

3. [ ] **With regard to the protest** against payment of (an) additional fee(s) under Rule 40.2, the applicant is notified that:

[ ] the protest together with the decision thereon has been transmitted to the International Bureau together with the applicant's request to forward the texts of both the protest and the decision thereon to the designated Offices.

[ ] no decision has been made yet on the protest; the applicant will be notified as soon as a decision is made.

4. **Further action(s):** The applicant is reminded of the following:

Shortly after **18 months** from the priority date, the international application will be published by the International Bureau. If the applicant wishes to avoid or postpone publication, a notice of withdrawal of the international application, or of the priority claim, must reach the International Bureau as provided in Rules 90*bis*.1 and 90*bis*.3, respectively, before the completion of the technical preparations for international publication.

Within **19 months** from the priority date, a demand for international preliminary examination must be filed if the applicant wishes to postpone the entry into the national phase until 30 months from the priority date (in some Offices even later).

Within **20 months** from the priority date, the applicant must perform the prescribed acts for entry into the national phase before all designated Offices which have not been elected in the demand or in a later election within 19 months from the priority date or could not be elected because they are not bound by Chapter II.

Name and mailing address of the International Searching Authority European Patent Office, P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Authorized officer Shantisaroop Pherai

Form PCT/ISA/220 (July 1998)

NOTES TO FORM PCT/ISA/220

These Notes are intended to give the basic instructions concerning the filing of amendments under article 19. The Notes are based on the requirements of the Patent Cooperation Treaty, the Regulations and the Administrative Instructions under that Treaty. In case of discrepancy between these Notes and those requirements, the latter are applicable. For more detailed information, see also the PCT Applicant's Guide, a publication of WIPO.

In these Notes, "Article", "Rule", and "Section" refer to the provisions of the PCT, the PCT Regulations and the PCT Administrative Instructions respectively.

INSTRUCTIONS CONCERNING AMENDMENTS UNDER ARTICLE 19

The applicant has, after having received the international search report, one opportunity to amend the claims of the international application. It should however be emphasized that, since all parts of the international application (claims, description and drawings) may be amended during the international preliminary examination procedure, there is usually no need to file amendments of the claims under Article 19 except where, e.g. the applicant wants the latter to be published for the purposes of provisional protection or has another reason for amending the claims before international pbulication. Furthermore, it should be emphasized that provisional protection is available in some States only.

What parts of the international application may be amended?

Under Article 19, only the claims may be amended.

During the international phase, the claims may also be amended (or further amended) under Article 34 before the International Preliminary Examining Authority. The description and drawings may only be amended under Article 34 before the International Examining Authority.

Upon entry into the national phase, all parts of the international application may be amended under Article 28 or, where applicable, Article 41.

When? Within 2 months from the date of transmittal of the international search report or 16 months from the priority date, whichever time limit expires later. It should be noted, however, that the amendments will be considered as having been received on time if they are received by the International Bureau after the expiration of the applicable time limit but before the completion of the technical preparations for international publication (Rule 46.1).

Where not to file the amendments?

The amendments may only be filed with the International Bureau and not with the receiving Office or the International Searching Authority (Rule 46.2).

Where a demand for international preliminary examination has been/is filed, see below.

How? Either by cancelling one or more entire claims, by adding one or more new claims or by amending the text of one or more of the claims as filed.

A replacement sheet must be submitted for each sheet of the claims which, on account of an amendment or amendments, differs from the sheet originally filed.

All the claims appearing on a replacement sheet must be numbered in Arabic numerals. Where a claim is cancelled, no renumbering of the other claims is required. In all cases where claims are renumbered, they must be renumbered consecutively (Administrative Instructions, Section 205(b)).

The amendments must be made in the language in which the international application is to be published.

What documents must/may accompany the amendments?

Letter (Section 205(b)):

The amendments must be submitted with a letter.

The letter will not be published with the international application and the amended claims. It should not be confused with the "Statement under Article 19(1)" (see below, under "Statement under Article 19(1)").

The letter must be in English or French, at the choice of the applicant. However, if the language of the international application is English, the letter must be in English; if the language of the international application is French, the letter must be in French.

The letter must indicate the differences between the claims as filed and the claims as amended. It must, in particular, indicate, in connection with each claim appearing in the international application (it being understood that identical indications concerning several claims may be grouped), whether

(i) the claim is unchanged;

(ii) the claim is cancelled;

(iii) the claim is new;

(iv) the claim replaces one or more claims as filed;

(v) the claim is the result of the division of a claim as filed.

The following examples illustrate the manner in which amendments must be explained in the accompanying letter:

1. [Where originally there were 48 claims and after amendment of some claims there are 51]:
"Claims 1 to 29, 31, 32, 34, 35, 37 to 48 replaced by amended claims bearing the same numbers; claims 30, 33 and 36 unchanged; new claims 49 to 51 added."

2. [Where originally there were 15 claims and after amendment of all claims there are 11]:
"Claims 1 to 15 replaced by amended claims 1 to 11."

3. [Where originally there were 14 claims and the amendments consist in cancelling some claims and in adding new claims]:
"Claims 1 to 6 and 14 unchanged; claims 7 to 13 cancelled; new claims 15, 16 and 17 added." or
"Claims 7 to 13 cancelled; new claims 15, 16 and 17 added; all other claims unchanged."

4. [Where various kinds of amendments are made]:
"Claims 1-10 unchanged; claims 11 to 13, 18 and 19 cancelled; claims 14, 15 and 16 replaced by amended claim 14; claim 17 subdivided into amended claims 15, 16 and 17; new claims 20 and 21 added."

"Statement under article 19(1)" (Rule 46.4)

The amendments may be accompanied by a statement explaining the amendments and indicating any impact that such amendments might have on the description and the drawings (which cannot be amended under Article 19(1)).

The statement will be published with the international application and the amended claims.

It must be in the language in which the international appplication is to be published.

It must be brief, not exceeding 500 words if in English or if translated into English.

It should not be confused with and does not replace the letter indicating the differences between the claims as filed and as amended. It must be filed on a separate sheet and must be identified as such by a heading, preferably by using the words "Statement under Article 19(1)."

It may not contain any disparaging comments on the international search report or the relevance of citations contained in that report. Reference to citations, relevant to a given claim, contained in the international search report may be made only in connection with an amendment of that claim.

Consequence if a demand for international preliminary examination has already been filed

If, at the time of filing any amendments under Article 19, a demand for international preliminary examination has already been submitted, the applicant must preferably, at the same time of filing the amendments with the International Bureau, also file a copy of such amendments with the International Preliminary Examining Authority (see Rule 62.2(a), first sentence).

Consequence with regard to translation of the international application for entry into the national phase

The applicant's attention is drawn to the fact that, where upon entry into the national phase, a translation of the claims as amended under Article 19 may have to be furnished to the designated/elected Offices, instead of, or in addition to, the translation of the claims as filed.

For further details on the requirements of each designated/elected Office, see Volume II of the PCT Applicant's Guide.

PATENT COOPERATION TREATY

PCT

INTERNATIONAL SEARCH REPORT

(PCT Article 18 and Rules 43 and 44)

Applicant's or agent's file reference	**FOR FURTHER ACTION**	see Notification of Transmittal of International Search Report (Form PCT/ISA/220) as well as, where applicable, item 5 below.
PEA		
International application No.	International filing date *(day/month/year)*	(Earliest) Priority Date *(day/month/year)*
PCT/IL 99/00476	01/09/1999	
Applicant		
INDIGO N.V. et al.		

This International Search Report has been prepared by this International Searching Authority and is transmitted to the applicant according to Article 18. A copy is being transmitted to the International Bureau.

This International Search Report consists of a total of 2 sheets.

[X] It is also accompanied by a copy of each prior art document cited in this report.

1. **Basis of the report**

   a. With regard to the **language**, the international search was carried out on the basis of the international application in the language in which it was filed, unless otherwise indicated under this item.

   [ ] the international search was carried out on the basis of a translation of the international application furnished to this Authority (Rule 23.1(b)).

   b. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international search was carried out on the basis of the sequence listing :

   [ ] contained in the international application in written form.

   [ ] filed together with the international application in computer readable form.

   [ ] furnished subsequently to this Authority in written form.

   [ ] furnished subsequently to this Authority in computer readble form.

   [ ] the statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   [ ] the statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished

2. [ ] **Certain claims were found unsearchable** (See Box I).

3. [ ] **Unity of invention is lacking** (see Box II).

4. With regard to the **title,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established by this Authority to read as follows:

5. With regard to the **abstract,**

   [X] the text is approved as submitted by the applicant.

   [ ] the text has been established, according to Rule 38.2(b), by this Authority as it appears in Box III. The applicant may, within one month from the date of mailing of this international search report, submit comments to this Authority.

6. The figure of the **drawings** to be published with the abstract is Figure No. 4

   [X] as suggested by the applicant.

   [ ] None of the figures.

   [ ] because the applicant failed to suggest a figure.

   [ ] because this figure better characterizes the invention.

INTERNATIONAL SEARCH REPORT

International Application No
PCT/IL 99/00476

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01J3/46 B41F33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01J B41F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 669 754 A (DAINIPPON SCREEN MFG) 30 August 1995 (1995-08-30)	1,11
X	page 12, line 20 - line 54	18
A	DE 32 21 812 A (GRETAG AG) 5 January 1983 (1983-01-05) page 7, line 1 -page 8, line 4	1,18
A	US 5 003 500 A (W. H. GERBER) 26 March 1991 (1991-03-26) column 3, line 68 -column 5, line 31	1,11,18
A	WO 98 46008 A (BARCO GRAPHICS N.V.) 15 October 1998 (1998-10-15)	
A	EP 0 065 484 A (GRETAG AG) 24 November 1982 (1982-11-24)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2000	04/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	De Roeck, A

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No
PCT/IL 99/00476

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
EP 0669754 A	30-08-1995	JP 7234158 A	05-09-1995
		DE 69506013 D	24-12-1998
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		US 5596425 A	21-01-1997
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US 5003500 A	26-03-1991	EP 0360738 A	28-03-1990
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WO 9846008 A	15-10-1998	US 5933578 A	03-08-1999
		EP 0974225 A	26-01-2000
EP 0065484 A	24-11-1982	JP 57192841 A	27-11-1982

CLAIMS

1. A method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, comprising:

specifying an apparent color;

estimating diffuse reflection from an outside surface of colorants when printed on the specified substrate; and

adjusting the specified color for the effects of the estimated diffuse reflection to determine a color to be used for computing the colorants.

2. A method according to claim 1 wherein the specified color is a color spectrum.

3. A method according to claim 1 or claim 2 wherein the specified apparent color is determined from a measurement of a printed exemplar.

4. A method according to any of the preceding claims and including determining a mixture of colorants based on the adjusted spectrum.

5. A method according to claim 4, including:

printing the mixture of colorants as separate separations on the substrate.

6. A method according to claim 5 wherein the separations are printed as half-tone configurations.

7. A method according to claim 5 or claim 6 wherein the colorants comprise at least one process color.

8. A method according to any of claims 5-7 wherein determining the mixture of color components comprises determining a percent coverage of the colorants of the separations on the substrate.

9. A method according to any of claims 5-8 and including correcting the estimate of diffuse reflection based on a percent coverage of the paper by the colorants and repeating the determination of the color mixture based on the corrected estimate.

10. A method according to claim 4 and including printing the mixture of colorants as a single layer of mixed colorant.

11. A method of determining the OD of a printed colorant, comprising:

determining a visible wavelength region in which the color is at or near saturation; and

if a portion of a determination of saturation is found, determining the OD in a wavelength region at which the color is not near saturation.

12. A method according to claim 11 and including, if none of the visible wavelength region is at saturation:

determining the OD in a wavelength region at which the spectrum of light reflected from the colorant is a minimum.

13. A method according to claim 11 or claim 12 and comprising:

acquiring a reflection spectrum of the printed colorant including at least a wavelength region in which the color is not near saturation, wherein the OD is determined based on a reflectance measurement at a wavelength in which the color is not in saturation.

14. A method according to claim 11 or claim 12 wherein determining the OD comprises:

filtering the reflection through a filter which passes at least a portion of the wavelength region in which the color is not in saturation; and

measuring the filtered reflection.

15. A method of choosing a filter for performing the method of claim 14 from a plurality of filters, comprising:

determining which of the filters in the plurality of filters blocks a maximum amount of the reflected light without saturation of the measurement; and

utilizing the thus determined filter to filter the reflection prior to measurement.

16. A method according to claim 14 or claim 15, wherein the colorant is a process color and wherein the plurality of filters comprise a filter associated with each of the process colors, each said filter selectively passing only wavelengths for which the colorant has a high absorption and including:

determining which of the filters that do not cause a saturation condition in the measurement of OD, blocks a maximum of the reflected light and

utilizing the thus determined filter to filter the reflection prior to measurement.

17. A method according to claim 16 wherein the filter is a filter other than the filter associated with the process color.

18. A method for determining the diffuse reflection from the surface of a printed colorant comprising;

printing the colorant with a thickness such that the color is saturated in a given wavelength band; and

measuring the diffuse reflection of light from the printed colorant in said wavelength band.

19. A method according to claim 18 wherein measuring the diffuse reflection comprises measuring the diffuse reflection of light from the surface through a filter that selectively passes light only in the given wavelength band.

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01J3/46 B41F33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01J B41F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0 669 754 A (DAINIPPON SCREEN MFG) 30 August 1995 (1995-08-30)	1,11
X	page 12, line 20 - line 54	18
A	DE 32 21 812 A (GRETAG AG) 5 January 1983 (1983-01-05) page 7, line 1 -page 8, line 4	1,18
A	US 5 003 500 A (W. H. GERBER) 26 March 1991 (1991-03-26) column 3, line 68 -column 5, line 31	1,11,18
A	WO 98 46008 A (BARCO GRAPHICS N.V.) 15 October 1998 (1998-10-15)	
A	EP 0 065 484 A (GRETAG AG) 24 November 1982 (1982-11-24)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

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WO 9846008 A	15-10-1998	US 5933578 A	03-08-1999
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(71) Applicant *(for all designated States except US)*: **INDIGO N.V.** [NL/NL]; 5 Limburglaan Street, NL-6221 SH Maastricht (NL).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **KRITCHMAN, Eli** [IL/IL]; Mota Gur Street 56, 69012 Tel Aviv (IL). **STEINHAUER, Jeffrey** [IL/IL]; Najara Street 51, 76566 Rehovot (IL). **SHUSTER, Michael** [IL/IL]; Moshe Dayan Street 90A/1, 67320 Tel Aviv (IL).

(74) Agents: **FENSTER, Paul** et al.; Fenster & Company Patent Attorneys, LTD., P.O. Box 10256, 49002 Petach Tikva (IL).

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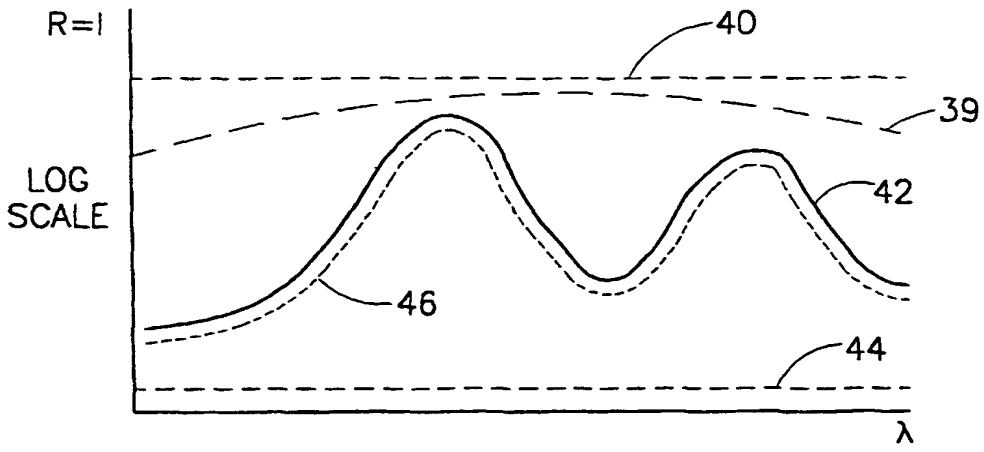
(54) Title: SYSTEM AND METHOD FOR ACCURATELY REPRODUCING COLOR



(57) Abstract: A method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, comprising: specifying an apparent color; estimating diffuse reflection from an outside surface of colorants when printed on the specified substrate; and adjusting the specified color for the effects of the estimated diffuse reflection to determine a color to be used for computing the colorants.

WO 01/16567 A1

SYSTEM AND METHOD FOR ACCURATELY REPRODUCING COLOR

FIELD OF THE INVENTION

The present invention relates to color printing and copying, and more particularly to accurately reproducing and measuring color regardless of the substrate on which it is produced.

BACKGROUND OF THE INVENTION

In order to reproduce color prints such as for printing, photography or copying, the spectrum of light that emerges from the printed colors is determined. The print is illuminated and the reflected light emerging therefrom is detected. A portion of the light directed to the surfaces of the print is absorbed and a certain amount of the light is transmitted through the colorant and reflected back through the colorant by the substrate. In the prior art, measurements are made of the spectral distribution of the illuminant (or more precisely of the reflection from an unprinted substrate), and the spectral reflectance of the printed substrate. The difference is assumed to be due to absorption by the colorant on the substrate.

However, in addition to the effect of the color of the substrate, it is known that the final apparent color of a print also depends on other characteristics of the substrate on which the color is printed or spread. This is true whether the color data for printing is computer generated or generated by scanning a physical image. Thus, when copies are made on both glossy and matte substrates, with the same colorant thickness, their apparent color is different.

Another problem in the printing field is matching the OD of a printed color with some desired value of color. In general, as the color saturation increases reflective methods become less sensitive and less accurate.

Fig. 1 illustrates a standard apparatus and methodology for measuring colors printed on a sheet. A light source 12 illuminates a sheet having a colored layer 14 printed on a sheet 16 at some angle to the normal to the sheet. A detector 18 which views the surface generally from a direction normal to the surface, receives light which passes through layer 14 and which is diffusely reflected 13 from the surface of sheet 16. Light source 12 is set at an angle so as to avoid specular reflection from the surface of color layer from affecting the color measurement. Diffuse reflection 15 from the surface of color layer 14, does affect the measurement. However, this measurement of the diffuse reflection mimics the apparent optical density seen by an observer, since the observer also views this diffusely reflected light. A series of filters is used to separate the color reaching the detector into spectral components, which breakdown is used to determine the apparent OD of each of the process colors required to reproduce the color or to enable preparation of a specially mixed color.

When the OD of a single patch of process or specially mixed color is being measured, a series of filters are sequentially placed between sheet 16 and detector 18. Each of these filters corresponds to one of the process colors and selectively passes the spectral band absorbed by that process color. The identity of the process color being tested can be determined from the filter which gives the lowest output for detector 18. The OD is determined from the amplitude of the light which reaches the detector with the color filter associated with the particular process color. Here again, the effects of specular reflection from the colored layer is avoided, but there is an effect of the diffuse reflection therefrom on the measurement. Of course, if the identity color being measured is known, a priori, as in an in-line densitometer, the measurement may be made immediately with the correct filter.

SUMMARY OF THE INVENTION

An aspect of some preferred embodiments of the invention is related to more accurate production of printed images, independently of the gloss of the substrate on which the images are being printed.

An aspect of some preferred embodiments of the invention is related to more accurate copying of printed images, while reducing the effect of gloss from the color accuracy.

An aspect of some preferred embodiments of the invention relates to compensation for the characteristics of the surface being printed upon.

In general, if the apparatus of Fig. 1 is used to measure the color spectrum of the colors of the printed surface and this measured spectrum is used to compute the percentage of coverage of primary colors for printing, or the color components used to mix a special color, the printed image will have a somewhat different color than that of the original image. Furthermore, this effect will depend on the finish of the master image and of the copy, and may exist even if the master and the copy have the same finish.

In accordance with a preferred embodiment of the invention, the effect of diffuse reflection from the surface of a color layer is separated from the effect of light that is diffusely reflected from the substrate after passing the color layer by which the color is printed or otherwise formed. The two components are preferably separately taken into account for both measurement purposes and for computation of the amounts of color that are to be printed (either as process colors or as color components of a special colorant), to achieve a required apparent color and optical density (OD).

In a preferred embodiment of the invention, a value "S" is determined that is dependent primarily on the gloss of the print. This factor corresponds to the diffuse light that is reflected from the surface of the color layer. In general it can be considered to be equal to the ratio of the

light measured from the printed substrate and the light measured from the underlying unprinted substrate. The glossier the print (often directly related to the gloss of the underlying substrate) the smaller S, since for glossy prints the specular reflection is high, but the diffuse reflection is low. The gloss of the print closely relates to the gloss of the substrate because of the relative thinness of the printed ink, especially for liquid inks and toners.

In a preferred embodiment of the present invention, to determine S, any color is thickly printed on a substrate. Preferably, the ink thickness is such that the diffused scatter from the surface of the printed color, in the wavelength band in which the color absorbs light, is much larger than the light that passes through the color layer, strikes the substrate and is reflected back to the detector or light sensor. A filter, which limits the light measured by the detector to that portion of the spectrum that is absorbed by the color layer, is placed in front of the detector, which in turn, determines the apparent OD.

With no light passing, within the band of the filter, passing through the colorant, the light measured by the detector is substantially only the light that is diffusely reflected from the surface of the colorant. The value S, which can be expected to be the same over the entire spectrum, is calculated from the inverse logarithm to the base 10 of the OD measured through the filter. Even though the scatter is measured only over a limited wavelength band, the value achieved may be assumed to be constant over the entire visible region, since the same scatter mechanism is operative over the entire visible spectrum.

With knowledge of the value of S for prints on the particular substrate, the measured spectrum (or the spectrum computed for a computer image) can be corrected to determine which portion of the desired apparent spectrum must be supplied by light that passes twice through the color layer. Since S will be supplied by the scatter from the surface, the amount to be supplied by the light that passes through the printed colors can be calculated. This correction will apply to whether the color is being reproduced with a series of halftone process color separations or with a single specially formulated colorant.

An aspect of some preferred embodiments of the invention is related to more accurate measurement of color OD of printed substrates.

An aspect of some preferred embodiments of the invention is related to the more accurate determination of the absorption of colored layers, independently of the gloss of the substrate on which the image is formed.

As indicated above, in the normal methodology of measuring the OD of printed surfaces, a filter, which is matched to the maximum absorption band of the particular colorant (ink or toner), is used to filter the light received by the detector. However, for high ODs, the

amount of light reflected from the outer surface of the colorant may be as high as that which passes through the colorant. Thus, when the measurements determine a lower than desired OD, an operator can not overcome this situation by increasing the thickness of the colorant.

Some preferred embodiments of the invention are meant to solve or reduce the effects of saturation on the measurement of OD of a printed patch of a given process or special color. Such patches are routinely used to determine if a proper thickness of colorant is being applied to the substrate. An operator measures the OD of the color (using the method described in the background) and adjusts the thickness of the colorant (either mechanically or electrically, dependent on the type of printer) to achieve the desired OD. However, when the colorant is near saturation (i.e., so thick that little light passes through it in the spectrum band of maximum absorbance), the measurement is inexact, since the main component measured using a filter which passes only this band, is diffuse reflection from the surface of the printed colorant layer.

In a preferred embodiment of the invention, an "incorrect" filter is used in the measurement of OD, whenever the filter usually used (i.e., that is matched to the colorant) blocks almost all the light that passes through the colorant (i.e., the system is in saturation).

In a preferred embodiment of the invention, for high OD values of a particular process color, the filter for a colorwise adjoining process color is used. Either, the detector system is calibrated to determine the OD of the printed color even though the "incorrect" filter is used or, alternatively, the operator is instructed to use an "incorrect" filter and given a value of OD to aim for, utilizing a detector that is calibrated in the normal manner.

This aspect of the invention can also be applied to the measurement of single color inks. In general such inks have a wide and varying absorption spectrum. Thus, while one portion of the spectrum may be in saturation, other, visually important portions may not be in saturation. If the measurement is made, as is usual, at wavelengths of maximum absorption, the measurement may become insensitive to thickness even though the actual appearance of the colorant layer is still changing substantially with thickness. In accordance with a preferred embodiment of the invention, a filter having a band outside the band of maximum absorption of the colorant is used.

This improved measurement of the quantity of the colorant on the substrate allows for proper coloration for less saturated regions of the spectrum.

There is thus provided, in accordance with a preferred embodiment of the invention, a method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, comprising:

specifying an apparent color;

estimating diffuse reflection from an outside surface of colorants when printed on the specified substrate; and

adjusting the specified color for the effects of the estimated diffuse reflection to determine a color to be used for computing the colorants.

In a preferred embodiment of the invention, the specified color is a color spectrum.

In a preferred embodiment of the invention, the specified apparent color is determined from a measurement of a printed exemplar.

Preferably, the method includes determining a mixture of colorants based on the adjusted spectrum. Preferably, the method includes printing the mixture of colorants as separate separations on the substrate. Preferably, the separations are printed as half-tone configurations.

In a preferred embodiment of the invention, the colorants comprise at least one process color.

Preferably, determining the mixture of color components comprises determining a percent coverage of the colorants of the separations on the substrate.

Preferably, the method includes correcting the estimate of diffuse reflection based on a percent coverage of the paper by the colorants and repeating the determination of the color mixture based on the corrected estimate.

In a preferred embodiment of the invention, the method includes printing the mixture of colorants as a single layer of mixed colorant.

There is further provided, in accordance with a preferred embodiment of the invention, a method of determining the OD of a printed colorant, comprising:

determining a visible wavelength region in which the color is at or near saturation; and

if a portion of a determination of saturation is found, determining the OD in a wavelength region at which the color is not near saturation.

In a preferred embodiment of the invention, the method includes, if none of the visible wavelength region is at saturation:

determining the OD in a wavelength region at which the spectrum of light reflected from the colorant is a minimum.

Preferably, the method includes acquiring a reflection spectrum of the printed colorant including at least a wavelength region in which the color is not near saturation, wherein the OD is determined based on a reflectance measurement at a wavelength in which the color is not in saturation.

In a preferred embodiment of the invention, determining the OD comprises filtering the reflection through a filter which passes at least a portion of the wavelength region in which the color is not in saturation and measuring the filtered reflection.

There is further provided, in accordance with a preferred embodiment of the invention a method of choosing a filter for performing a preferred method of the invention from a plurality of filters, comprising:

determining which of the filters in the plurality of filters blocks a maximum amount of the reflected light without saturation of the measurement; and

utilizing the thus determined filter to filter the reflection prior to measurement.

In a preferred embodiment of the invention, wherein the colorant is a process color and wherein the plurality of filters comprise a filter associated with each of the process colors, each said filter selectively passes only wavelengths for which the colorant has a high absorption and including:

determining which of the filters that do not cause a saturation condition in the measurement of OD, blocks a maximum of the reflected light and

utilizing the thus determined filter to filter the reflection prior to measurement.

Preferably, the filter is a filter other than the filter associated with the process color.

There is further provided, in accordance with a preferred embodiment of the invention, a method for determining the diffuse reflection from the surface of a printed colorant comprising;

printing the colorant with a thickness such that the color is saturated in a given wavelength band; and

measuring the diffuse reflection of light from the printed colorant in said wavelength band.

Preferably, measuring the diffuse reflection comprises measuring the diffuse reflection of light from the surface through a filter that selectively passes light only in the given wavelength band.

BRIEF DESCRIPTION OF THE DRAWING

The above described, and other objects and features of the present invention will be best understood when considered in light of the following non-limiting description made in conjunction with the accompanying drawings; wherein:

Fig. 1 shows a detector for detecting optical density of printed substrates and for determining the color components of a printed image area;

Fig. 2A is a flow chart of a method for determining the correct process colors for printing on a substrate to achieve a desired color spectrum, in accordance with a preferred embodiment of the invention;

Fig. 2B is a flow chart of a method for determining the correct color mixture for a special colorant for printing on a substrate to achieve a desired color spectrum, in accordance with a preferred embodiment of the invention;

Fig. 3 shows a flow chart of a method of determining the reflectance S, in accordance with a preferred embodiment of the invention; and

Fig. 4 shows various spectra useful in understanding preferred embodiments of the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Fig. 2A shows a flow chart which outlines a method 20, for determining the correct colors for printing on a substrate to achieve a desired color spectrum, in accordance with a preferred embodiment of the invention. First a desired color reflectance spectrum for the printed area is determined (22). This desired spectrum may be defined by a computer or may be the result of measurement of a sample image whose spectrum is measured in accordance with methods of the prior art, as described, for example with respect to Fig. 1 in the background section hereof. Furthermore, this spectrum may be defined in terms of percent coverage of process color inks or toners. Preferably, for the preferred embodiment of the invention, the actual spectrum is computed or estimated from the coverage percentages.

This desired reflectance spectrum can be considered as being comprised of two parts. One part is the diffuse reflection from the surface of the colorant being printed. A second part is the diffuse reflection from the underlying substrate 16 *on which an image is to be printed*, either after it passes (twice) through the colorant or in areas for which no colorant is present. The sum of the two diffuse reflections determines the color that will be seen by an observer, assuming there is no specular reflection (glare). Since glare is avoid instinctively by a viewer, this sum is equal to the target reflectance spectrum for printing.

In order to separate the target spectrum into two parts for computation of colorant coverage, the target reflectance spectrum is reduced (24) by the scattered (diffuse) reflectance "S" of a surface colorant as printed on the paper or other substrate on which the image is to be printed. A method of determining this reflectance is described below. An initial value of S based on a value for 100% coverage as derived below, is estimated and then corrected in the manner described below.

The coverage for each of the process colors is then determined (26) in any conventional manner known in the art, utilizing the spectrum as reduced by the reflectance S, rather than the measured or defined reflectances. The usual implicit assumption that the diffuse and specular reflection from the unprinted portions of the paper is the same as for the paper underlying the colorant, is made. The reflectance of the paper or other substrate is most preferably also known/measured, to more precisely determine the proper coverage.

It is assumed that the scattering is a constant fraction s of the incident light and depends on the type of paper (for liquid inks). It may be about 2% for copy paper, which is rough and 0.2% for glossy paper. In effect, it adds a white component to the color. The reflectance of the ink layer then becomes: $\rho(\lambda)=s + (1-s)\ S(\lambda)\ \rho_b(\lambda)$, where $S(\lambda)$ is the reflectance of the substrate and $\rho_b(\lambda)$ is the reflectance contributed by the colorant layer itself (assuming no gloss and pure white light and paper). For a given measured or desired apparent reflectance $\rho(\lambda)$, the colorant contribution $\rho_b(\lambda)$, can be computed. By integration over the spectrum (or rather over portions of the spectrum) all the calorimetric parameters, the tristimulus parameters X, Y, Z (or L*, a*, b*) OD etc., can be computed

The computed coverage for all of the process colors is computed and sent to circuitry 29 for computing S (which circuitry may be a computer such as the computer or controller of the printer). This circuitry computes the expected overall coverage of all of the half tone separations and, from this coverage, a new value of S for the computation. One or two iterations may be necessary for the value of S to converge. Alternatively this correction may be omitted and a value of S estimated based on the spectrum.

Alternatively, a special colorant is designed to produce the reflection reduced spectrum. Fig. 2B shows, in flow chart form, a method 50 for determining the mixtures of inks to be used. As in method 20, the spectrum is defined and reduced by S (22, 24). Since coverage for such a mix is generally 100%, no correction is necessary for S. However, if the special ink is to be printed in halftone, such correction may be required. To determine the mix of inks and the printing thickness required for the final product (52), the spectra of the inks used for mixing must be known or measured. This ink is then mixed, tested, and if necessary the mix and/or the thickness are (54) adjusted to achieve the desired apparent color.

These colors are then printed (28) in any manner known in the art.

Fig. 3 shows a flow chart of a method (30) of determining the reflectance S, in accordance with a preferred embodiment of the invention.

A substrate of the type on which the final image is to be printed is printed (32) with a relatively thick layer of one of the colors. The amount of scattered light from the colorant

surface does not vary much from one colorant to another within a particular technology. Therefore this test may be performed with any color of colorant, and the measured S applied to all the colors. The printed color should be thick enough such that the amount of light that passes through the layer and is diffusely reflected from the paper (through the layer) to the detector is small, compared to the amount of light diffusely reflected from the surface of the substrate. The reflection from the surface of the colorant is then measured (34), using the conventional methodology (or any other methodology) shown in Fig. 1. If a process colorant is used, then a filter that passes only wavelengths absorbed by the colorant are preferably used. If black colorant is used, any or no filter can be used. If a spectrometer is used, the spectral band of minimum reflectance characterizes S. Since the measured reflection is not dependent on the color, but only on the surface characteristics of the colorant, the reflectance is assumed (unless some variation is known or suspected) to be the same over the entire spectrum.

It should be understood that S need not be measured for each print job, but may be measured once for each combination of colorant type and substrate and used for all subsequent print jobs.

In most cases the thickness of the colorant is not critical for this measurement. For inks and liquid toners, the colorant is relatively thin and the surface finish of the printed portion is very similar to that of the underlying substrate, for any reasonable colorant thickness. On the other hand, for materials such as powder toner, the image gloss is only weakly dependent on the surface qualities of the underlying substrate. Of course, if the image is treated (as with a gloss enhancing roller) to change its surface gloss, the determination of S should be performed on a test print similarly treated.

Fig. 4 shows the various spectra referred to in the above description. These can be considered as either reflectance spectra "R" or intensity spectra "I". The (diffuse) reflectance spectrum of a "calibration white" (39) substrate is taken as a reference (40) . This reference is shown as a straight line, under the assumption that calibration white is "pure white." It is understood that any deviation of the substrate from pure white is preferably compensated for in the usual manner. Reference 42 designates the desired reflectance spectrum on a log scale with respect to the reference. As indicated above, this spectrum may be determined by measurement of an exemplar to be reproduced or by a computer. (Reference 22 of Fig. 2.) Reference 44 designates the diffuse reflectance, S, from the surface of the colorant. (Reference 36 of Fig. 3.) Reference 46 designates the "corrected" spectrum to be used for computing coverage of the ink. (Reference 28 of Fig. 2)

Another aspect of the invention is meant to solve or reduce the effects of saturation on the measurement of OD of a printed patch of a given process or special color. Such patches are routinely used to determine if a proper thickness of colorant is being applied to the substrate. An operator measures the OD of the color (using the method described in the background) and adjusts the thickness of the colorant (either mechanically or electrically, dependent on the type of printer) to achieve the desired OD. However, when the colorant is near saturation (i.e., so thick that little light passes through it in the spectrum band of maximum absorbance), the measurement is inexact, since the main component measured using a filter which passes only this band, is diffuse reflection from the surface of the printed colorant layer.

In a preferred embodiment of the invention, an "incorrect" filter is used in the measurement of OD, whenever the filter usually used (i.e., that is matched to the colorant) blocks almost all the light that passes through the colorant (i.e., the system is in saturation).

In general three color filters and a filter for black are used in measurement, namely a yellow filter (which passes only light absorbed by the yellow colorant and which is the "correct" filter for measuring OD of the yellow colorant); a cyan filter (which passes only light absorbed by the cyan ink and which is the "correct" filter for measuring OD of the cyan colorant) and a magenta filter (which passes only light absorbed by the magenta ink and which is the "correct" filter for measuring OD of the cyan colorant). A broadband filter is used for black. Since, when the colorant is near saturation (defined as where the diffuse reflection from the surface of the colorant, which amount is dependent on the gloss of the colorant is comparable to that of the light reflected through the colorant), measurements made with the "correct" filter are not correctly affected by the colorant thickness, another filter is used to determine the thickness (by equivalent OD).

In a preferred embodiment of the invention, the filter to be used for measuring the OD is chosen based on its meeting two criteria. First it must not produce a saturation or near saturation condition. Since the spectra of the filters include spectral regions which have little absorption by the particular process color ink, this is seldom a problem for any filter except the "correct" one, for process colors. The second criteria is that the expected OD to be measured when using the filter be a maximum as compared to that measured by the other two filters. Thus, when a given colorant (as printed) when measured with its correct filter, is not in saturation, the "correct" filter is used, since it all the filters meet the first criteria and the correct filter best meets the second criteria. However, when using the first filter results in saturation or near saturation, another filter, which best meets the second criteria, is used.

For special inks, more than one filter may provide saturated measurements. In this case, the filter that provides unsaturated measurements is used. If none are in saturation, the measurement utilizing the highest OD is used.

In a preferred embodiment of the invention, tables which translate measured OD utilizing an "incorrect" filter to actual OD of the colorant being measured are derived either from actual measurements or from calculations based on the band pass of the various filters and on the spectra of the colorants, which, for process colors, are standardized and for special colors can be computed from the mixtures used.

In accordance with a preferred embodiment of the invention, tables are prepared or recommended measurements of OD are determined for various ODs of the process colors when the "incorrect" filter is used. The increased ODs can be measured in at least three ways.

Whenever a printed layer is believed by a user to be in saturation the "incorrect" filter and corresponding table would be used.

In a digital (and in some other computer controlled) printing systems, where the OD measurement is made by an operator, the tables are stored in a computer associated with the printer. For each color believed to be near saturation, the computer recommends the use of a best "incorrect" filter and gives a target value of "OD" as the target value for measurement with the "incorrect" filter.

It should be understood that as a practical measure software for carrying out the present invention may be supplied in the form of software on a suitable recording medium such as a diskette or CD ROM or for downloading (using the web or by direct transfer) or in the form of patch on existing software.

Where an in-line OD measurement is made in a digital of other computer controlled printer, the printer automatically determines the best filter that meets the above mentioned criteria and uses that filter and the above mentioned tables to determine the OD.

As used herein, the terms "comprise", "include" and "have" and their conjugates mean "including but not necessarily limited to".

While the invention has been described with reference to best mode embodiments, it should be understood that these embodiments are exemplary only and are not meant to act as limitations on the scope of the invention, which is defined by the accompanying claims. In addition each of the embodiments of the invention is described with reference to certain features. These features may be combined in additional preferred embodiments of the invention and some preferred embodiments of the invention may omit certain features of the described embodiments.

CLAIMS

1. A method of determining an adjusted color to be used for computing colorants for printing on a specified substrate, comprising:

specifying an apparent color;

estimating diffuse reflection from an outside surface of colorants when printed on the specified substrate; and

adjusting the specified color for the effects of the estimated diffuse reflection to determine a color to be used for computing the colorants.

2. A method according to claim 1 wherein the specified color is a color spectrum.

3. A method according to claim 1 or claim 2 wherein the specified apparent color is determined from a measurement of a printed exemplar.

4. A method according to any of the preceding claims and including determining a mixture of colorants based on the adjusted spectrum.

5. A method according to claim 4, including:

printing the mixture of colorants as separate separations on the substrate.

6. A method according to claim 5 wherein the separations are printed as half-tone configurations.

7. A method according to claim 5 or claim 6 wherein the colorants comprise at least one process color.

8. A method according to any of claims 5-7 wherein determining the mixture of color components comprises determining a percent coverage of the colorants of the separations on the substrate.

9. A method according to any of claims 5-8 and including correcting the estimate of diffuse reflection based on a percent coverage of the paper by the colorants and repeating the determination of the color mixture based on the corrected estimate.

10. A method according to claim 4 and including printing the mixture of colorants as a single layer of mixed colorant.

11. A method of determining the OD of a printed colorant, comprising:

determining a visible wavelength region in which the color is at or near saturation; and

if a portion of a determination of saturation is found, determining the OD in a wavelength region at which the color is not near saturation.

12. A method according to claim 11 and including, if none of the visible wavelength region is at saturation:

determining the OD in a wavelength region at which the spectrum of light reflected from the colorant is a minimum.

13. A method according to claim 11 or claim 12 and comprising:

acquiring a reflection spectrum of the printed colorant including at least a wavelength region in which the color is not near saturation, wherein the OD is determined based on a reflectance measurement at a wavelength in which the color is not in saturation.

14. A method according to claim 11 or claim 12 wherein determining the OD comprises:

filtering the reflection through a filter which passes at least a portion of the wavelength region in which the color is not in saturation; and

measuring the filtered reflection.

15. A method of choosing a filter for performing the method of claim 14 from a plurality of filters, comprising:

determining which of the filters in the plurality of filters blocks a maximum amount of the reflected light without saturation of the measurement; and

utilizing the thus determined filter to filter the reflection prior to measurement.

16. A method according to claim 14 or claim 15, wherein the colorant is a process color and wherein the plurality of filters comprise a filter associated with each of the process colors, each said filter selectively passing only wavelengths for which the colorant has a high absorption and including:

determining which of the filters that do not cause a saturation condition in the measurement of OD, blocks a maximum of the reflected light and

utilizing the thus determined filter to filter the reflection prior to measurement.

17. A method according to claim 16 wherein the filter is a filter other than the filter associated with the process color.

18. A method for determining the diffuse reflection from the surface of a printed colorant comprising;

printing the colorant with a thickness such that the color is saturated in a given wavelength band; and

measuring the diffuse reflection of light from the printed colorant in said wavelength band.

19. A method according to claim 18 wherein measuring the diffuse reflection comprises measuring the diffuse reflection of light from the surface through a filter that selectively passes light only in the given wavelength band.

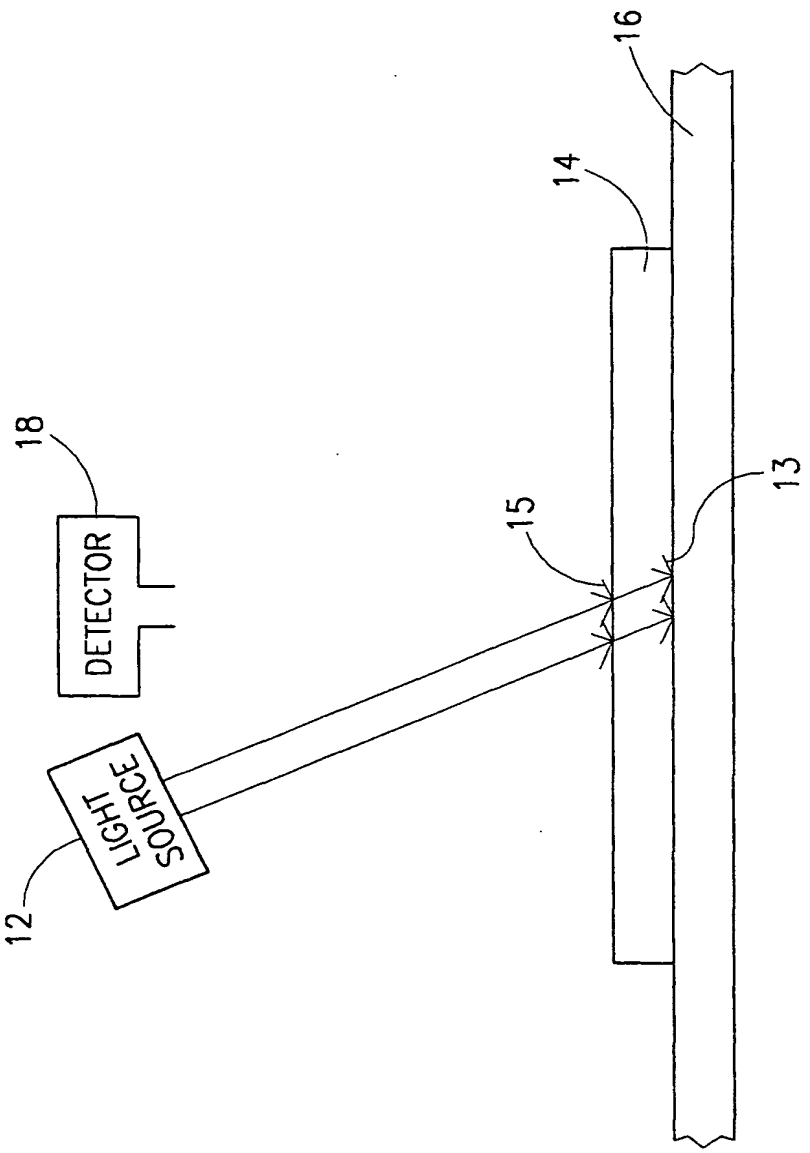


FIG.1

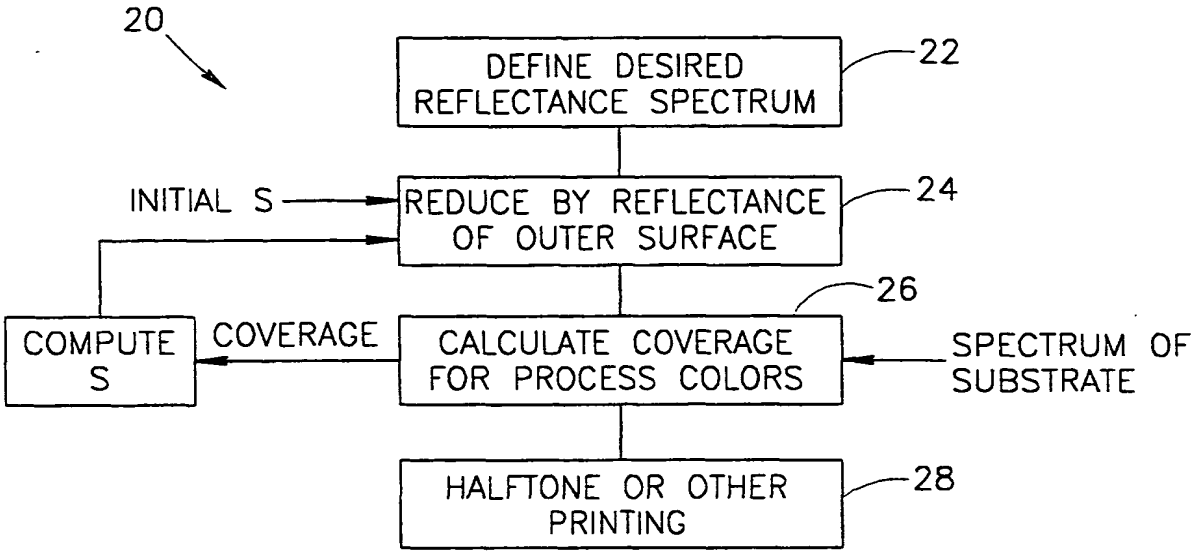

20
DEFINE DESIRED REFLECTANCE SPECTRUM
22
INITIAL S
REDUCE BY REFLECTANCE OF OUTER SURFACE
24
26
COMPUTE S
COVERAGE
CALCULATE COVERAGE FOR PROCESS COLORS
SPECTRUM OF SUBSTRATE
HALFTONE OR OTHER PRINTING
28

FIG.2A

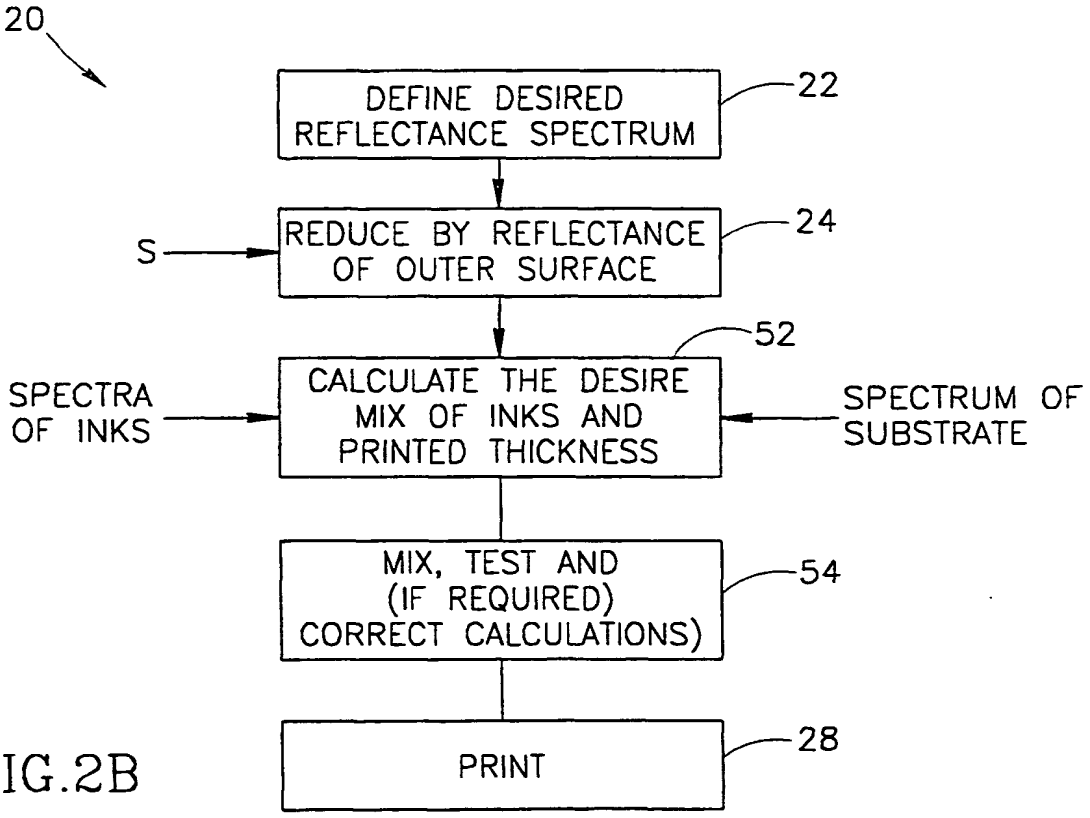
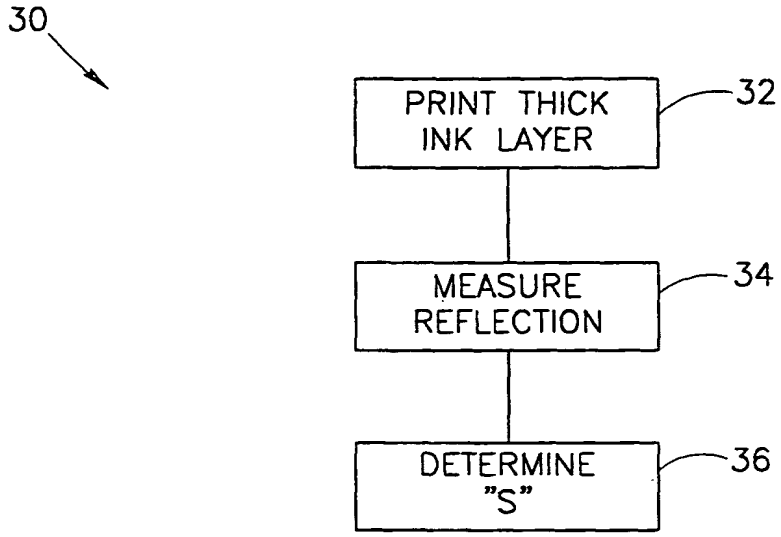

20
DEFINE DESIRED REFLECTANCE SPECTRUM
22
S
REDUCE BY REFLECTANCE OF OUTER SURFACE
24
52
SPECTRA OF INKS
CALCULATE THE DESIRE MIX OF INKS AND PRINTED THICKNESS
SPECTRUM OF SUBSTRATE
MIX, TEST AND (IF REQUIRED) CORRECT CALCULATIONS)
54
PRINT
28

FIG.2B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PRINT THICK INK LAYER
32
MEASURE REFLECTION
34
DETERMINE "S"
36

FIG.3

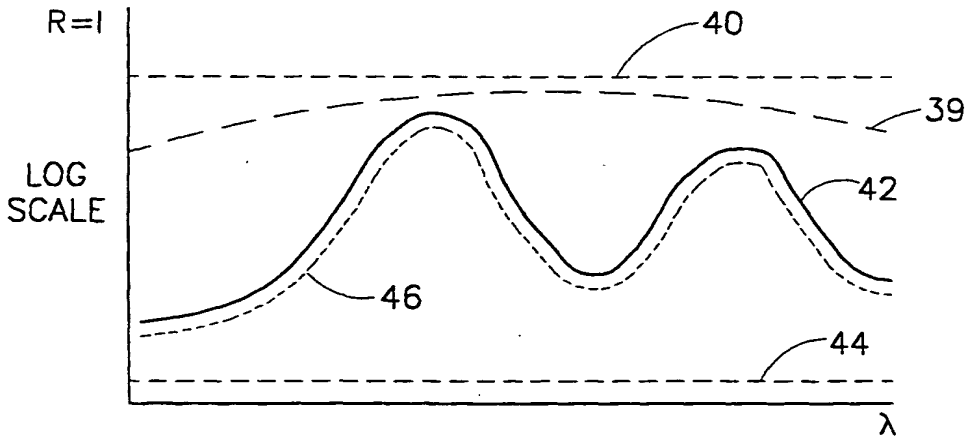
R=1
40
39
LOG SCALE
42
46
44
λ

FIG.4

INTERNATIONAL SEARCH REPORT

Int[illegible]ional Application No
PCT/IL 99/00476

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 G01J3/46 B41F33/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 G01J B41F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	page 12, line 20 - line 54	18
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A	WO 98 46008 A (BARCO GRAPHICS N.V.) 15 October 1998 (1998-10-15)	
A	EP 0 065 484 A (GRETAG AG) 24 November 1982 (1982-11-24)	

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

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"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
27 April 2000	04/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31–70) 340–2040, Tx. 31 651 epo nl, Fax: (+31–70) 340–3016	De Roeck, A

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Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

Information on patent family members

Int ational Application No
PCT/IL 99/00476

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